

SHIP PRODUCTION COMMITTEE  
FACILITIES AND ENVIRONMENTAL EFFECTS  
SURFACE PREPARATION AND COATINGS  
DESIGN/PRODUCTION INTEGRATION  
HUMAN RESOURCE INNOVATION  
MARINE INDUSTRY STANDARDS  
WELDING  
INDUSTRIAL ENGINEERING  
EDUCATION AND TRAINING

June 1977  
NSRP 0003

# **THE NATIONAL SHIPBUILDING RESEARCH PROGRAM**

## **Proceedings of the REAPS Technical Symposium**

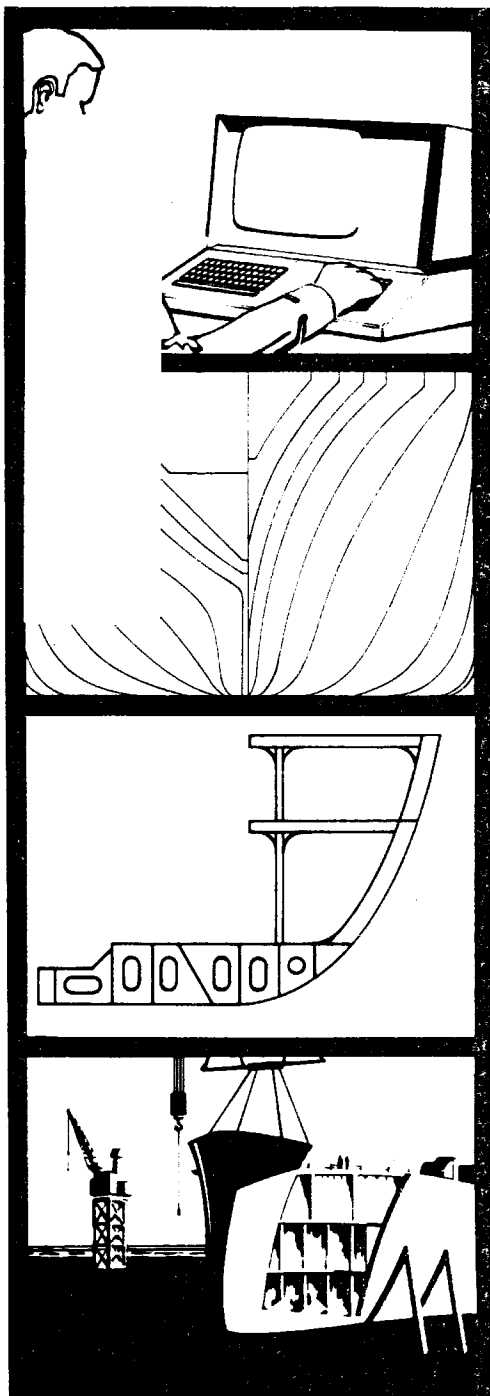
### **Paper No. 2: N/C Justification in the Shipyard**

U.S. DEPARTMENT OF THE NAVY  
CARDEROCK DIVISION,  
NAVAL SURFACE WARFARE CENTER

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>JUN 1977</b>		2. REPORT TYPE <b>N/A</b>		3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>The National Shipbuilding Research Program: Proceedings of the REAPS Technical Symposium Paper No. 2: N/C Justification in the Shipyard</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192, Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>SAR</b>	18. NUMBER OF PAGES <b>26</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

## DISCLAIMER

These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, "Persons acting on behalf of the United States Navy" includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.



**R** ESEARCH  
**E** AND  
**E** NGINEERING  
**A** FOR  
**A** UTOMATION  
**P** AND  
**S** RODUCTIVITY  
IN  
SHIPBUILDING

**Proceedings of the  
REAPS Technical Symposium  
June 21-22, 1977  
New Orleans, Louisiana**

## N/C JUSTIFICATION IN THE SHIPYARD

Charles M. French  
Bath Iron Works  
Bath, Maine

Mr. French is responsible for reducing ship production costs. This involves evaluating potential improvements, selecting the most cost effective one, preparing detailed justification for management, and insuring implementation of approved changes.

His past experience with Bath Iron Works has involved working on the MarAd Ship Producibility Research Program to reduce the cost of commercial ship construction, managing the company's energy conservation program, and justifying the N/C plate burning investment.

## N/C JUSTIFICATION IN THE SHIPYARD

Changing to computer-aided lofting and N/C burning from tenth scale, as Bath Iron Works is in the process of doing now, is a traumatic experience. The fact that there are so many other yards successfully using it for the past several years is certainly some comfort, but by no means eliminates the anxiety. This change in process has the potential for changing more people's jobs than, any other change at BIW in many, many years. This realization has been one factor that has caused the task of gaining the necessary capital approval to start N/C burning to be a long, drawn out affair. There has been a tremendous amount of mystery surrounding how the black box can actually do the things that a human being can do only with years of experience and a sense of judgment. How can a black box exercise judgment? .

But that aura of mystery only contributed to the more tangible problems we faced during the long, arduous task of getting approval for N/C.

At one point about five years ago when the decision was almost made to go ahead, no capital money was available. The subject simply went into a state of limbo a-rid then faded away as time passed.

About three years ago N/C was revived, but most of the discussion centered on whether BIW should use AUTOKON or SPADES . Possibly because there had not already been a firm

decision to make the change to N/C burning before attempting to select which computer system should be used for driving the burning machine, that argument went unresolved, thus causing the subject of N/C to again become suspended. The next and final attempt began over a year ago when the present Industrial Engineering department was organized. One of the first major projects assigned the new department was to again evaluate the feasibility of going to N/C burning.

Many yards that have N/C today have obtained approval based on the many intangible benefits that are inherent to N/C systems. A broad bracket of potential dollar savings can be placed around these benefits, but measurable savings is very different if not impossible to determine. Simply citing the 5 - 15% saving in steel labor that AUTOKON claims is the result yards have experienced, or the 25 - 33% SPADES claims to have saved the yards using their system simply carries no more weight with our management than being a point of reference for dollar savings. It is in no way a statement of a fact that can both be proven to have occurred and can be expected with confidence to occur at BIW.

The information put out by the suppliers includes words such as it is assured that or our own experience plus information from shipyards indicates that X% of manhours per ton can be saved with this system. They go on to explain that a certain percentage will be saved in scrap, and another percentage reduction in lofting manhours can occur and some other percentage in welding. We are then to add the various percentages, multiply times the steel weight of a ship, multiply that times the labor and

overhead rates and finally the answer is that so many million dollars per ship will be saved. That analysis may have worked. for some of the shipyards that have acquired N/C lofting and burning, but it would not work at BIW. Approval of capital expenditures here starts with the question, "What's the effect on the bottom line?" From there we go to, "What's the percentage return on investment and how many years is the payback period?" Next, "Prove the source of each and every number used to arrive at those answers."

This investment in a complete N/C burning system with computer-aid design and lofting represents one-half of the dollars we are presently spending annually on capital equipment. A project of &at magnitude receives very close attention to detail during the approval cycle.

It does not take very long to come to the conclusion that you cannot back up those answers found in the publications presently available with hard facts. We found that detailed backup information on which the percentage savings is based was simply not available.

That's the end of that - no approval.

Six folders of data on N/C burning that had been gathered during evaluation in the previous five years was studied to see if certain pertinent facts could be extracted and a justification put together without another full-blown effort. Dollar savings based on objective, specific facts could not be found in the files. Since a formal written presentation had not



been put together, what the files contained, by and large, was isolated facts. A logical progression of what computer-aided lofting is, how it compares to full scale and 1/10th scale lofting, and what N/C burning will do to improve production didn't exist either.

What did exist, however, were very strong opinions among most of the people who had been involved in the previous studies about what was right and what was wrong. Many preconceived notions were held strongly about our needs for new equipment, what systems were best and what should be bought.

The problem was finally defined by management as: (1) our old 1/10th scale burning machines are about to collapse and should be replaced before it's too late; (2) N/C burning must be a good technique for shipbuilding because so many yards are using it; and (3) since N/C must be the answer, provide the necessary justification so it can be purchased, considering that (a) two previous attempts failed, and (b) there doesn't appear to be enough tangible evidence readily available to convincingly settle the advisability of the investment.

Early on, MarAd suggested to us that it may be most productive to pursue the job of getting N/C approved if we first decided if N/C per se was an economical investment for BIW, and secondly to make an evaluation to decide which system would be used -- AUTOKON, SPADES, STEERBEAR, or some other,

It took some time for the importance of that advice to become clear. The question can be stated simply: "If more than one brand of automobile will get you from one place to another in the style you require, shouldn't you first decide if you even need a new car at all before you start worrying about whether it should be a Ford or a Chevy?" If you spend all your time on the process of selecting the brand, next year's model may be out before your decision is made.

The value of that advice was not, however, considered to be of great importance at the time a plan was established to analyze the needs of our Fab Shop and justification of Numerical Control. It was coincidental that the study was constructed in such a manner that it worked out that the benefits of computer-aided lofting and N/C plate burning were evaluated first and selection of a brand followed as a separate decision later.

The approach taken was to determine:

- 1) What are our present real needs and needs for the next five years?
- 2) If new burning equipment is needed, what are the cost and benefit comparisons of N/C with 1/10th scale optical burning machines similar to the present equipment?

In retrospect it was beneficial that the assumption was made at the outset that the need for new burning machines was not necessarily a foregone conclusion, let alone the notion that an N/C burning machine was a necessity. In the organization of BIW there is a long distance from the production floor to the board room of the directors of Congoleum, our parent company. Attaining the approval of corporate directors located in Milwaukee, Wisconsin for investing over a million dollars in one project for an old shipyard subsidiary in Bath, Maine, that hasn't been adding many dollars to the corporate profit line over the past several years requires more than a statement by Bath Iron Works management that "we know that this capital investment is really good and your approval is, therefore, requested. "

It was decided that we would take a new look at N/C by starting fresh. The old files were put in a drawer and a short study made to see if common problems seem to be inherent to getting numerically controlled machines approved in the business community in general. Perhaps we weren't unique. At the very least, the methods that we had been using were not successful.

The study was structured by specific tasks. The titles and condensed results of the tasks are as follows:

- 1) Present Loading

Actual labor hours were calculated per plate for Ro/Ro and FFG from 1975 returns and factors

developed for the unplanned "add-work" and special sequences that reduce time available for production.

2) Maintenance Downtime as a Percentage of Production Time

#1 and #2 Telerex - 9.2% and 9.3%

Flame Planer - 5% .

#1 and #2 CM - 2% and 0.7%

3) Machine Layout/Material Flow Chart - made for the present situation

- Aluminum Deck House Fabrication Location for FFG - Hardings or Bath?

Hardings will cut the plate and, therefore, needs a cutting capability that is faster and requires less flow disruption and handling problems than the present process of sawing. Gas cutting is incapable of processing non-ferrous metals.

4) Material Breakdown and Annual Mix Analysis

Quantities of plates have been identified for each burning operation for Ro/Ro, FFG and Industrial to route quantities of materials to each burning operation for loading purposes.

- Five Year Business Plan - Ship and Industrial:  
the highest capacity strain situation was determined.

5) Machine Capability

Operating tolerances for each machine were measured and judged to be adequate.

- 6) Annual Machine Load for the Five Year Plan  
CM-56 ' S - 3 shifts, 6 days/week  
Flame Plane - 2 shifts, 5 1/2 days/week  
TelereX's - 3 shifts, 6 days/week
- 7) Performance Needs for a New Machine  
Desirable burning functions and machine features have been defined, along with plate sizes and materials that will be processed to determine equipment requirements.
- 8) Repair/Rebuild the Present TelereX's  
Mechanical rebuild has been performed on both machines, but it is not economical to recondition the hard-wired, tube-type electrics: cost is \$100,000 each for electrical refurbish with no measurable savings resulting.
- 9) Replacement of present TelereX with comparable 1/10th Scale Optical Directed machine: No savings
- 10) The N/C Plan Task was, in essence, the resulting proposal submitted to management.
- 11) Evaluate Costs/Benefits  
The financial analysis indicates the return on investment is 28.4%, payback period is 4 years; several intangible benefits are discussed elsewhere.
- 12) Prepare the Proposal for Management Action.
- 13) Technical specifics for all equipment purchase orders.

## CAN AN N/C SYSTEM BE JUSTIFIED AT BIW?

As soon as the study was under way, it became apparent that common problems of gaining approval of N/C equipment did exist - in most industries. Often justification of the large investment required for the first numerical control machine tool that a company acquires has been very difficult in most industries. The problems are due to the many functions that are affected by the new process. There are two basic approaches that are usually taken to analyzing the savings that can be anticipated:

- 1) Identify all areas (production, material control, quality, clerical, etc.) that may be affected by N/C and estimate a dollar savings; or
- 2) Quantify the dollar savings only in the areas that are significantly affected and can have the results measured in an audit. All other areas that are affected to a nebulous degree are simply treated verbally - no specific dollar savings is claimed.

The second approach has been taken in this evaluation of using N/C at BIW. It was decided that if there is not enough specific, attainable savings without including nebulous possibilities to justify the investment, it would be unwise to acquire the system.

### N/C OR NOT?

Is N/C the panacea for all shipyards, or are there certain conditions that must exist before it becomes beneficial?

Does it depend on ship type and size, or shipyard size, or are there other alternatives available today which provide meaningful competition to N/C production machines? As may be obvious, there are no easy, clear-cut answers to these questions, as they involve many factors which are not even constant from one shipyard to another. However, from the experience of shipyards using at least some aspect of N/C, it can generally be stated that N/C applications have always improved the process and resulted in economic savings, regardless of the above-mentioned factors.

Guidelines for the use of N/C in other industries can be studied as a decision aid for a shipyard. It is claimed that a company is ready for N/C when:

1. The number of identical job-runs is relatively small:  
This is certainly true of ship parts. The number of identical parts is relatively small even for a tanker. Manual drawing or template manufacture time is always greater than that required for N/C data processing.
2. The average part has a fair degree of complexity:  
Computer-aided programming systems can handle complexity better and quicker than manual methods. Significant savings in time and reduction in scrap are obtainable with N/C. Obviously, the more complex the ship, the more the advantage of N/C. However, even for simple parts, the increased accuracy and simple control with N/C improves results.

3. The parts are subject to frequent design change:

This is, unfortunately, so in shipbuilding. N/C allows changes to be implemented quickly, providing the capability for processing and managing such changes has been built into the organization.

4. Inspection procedures are lengthy,difficult and, therefore, costly:

With N/C, the inspection can be performed by checking drawings prepared from the N/C tape.

The only:checks that must be made of the actual cut parts are to ensure machine accuracy.

The above items are easily definable and when considered directly, show N/C to be competitive. However, the main benefits which accrue from the use of N/C far exceed the above considerations and are usually the reasons for a company to implement N/C. The indirect benefits such as better management and control, which are possible with the use of an N/C system, are also of considerable significance.

The approval of the project at BIW rested almost completely on the return shown in the financial analysis. The final results of the financial analysis were based on the marketing projection of ships that would be built and the quantified labor savings in fitting and welding for each hull. The development of the labor savings is the heart of the N/C justification.



PRESENT

JOINT OPENINGS

52%	0 - 1/16 INCH
22%	1/16 - 1/8 INCH
18%	1/8 - 1/4 INCH
8%	+ 1/4 INCH

# LABOR HOURS PER FOOT

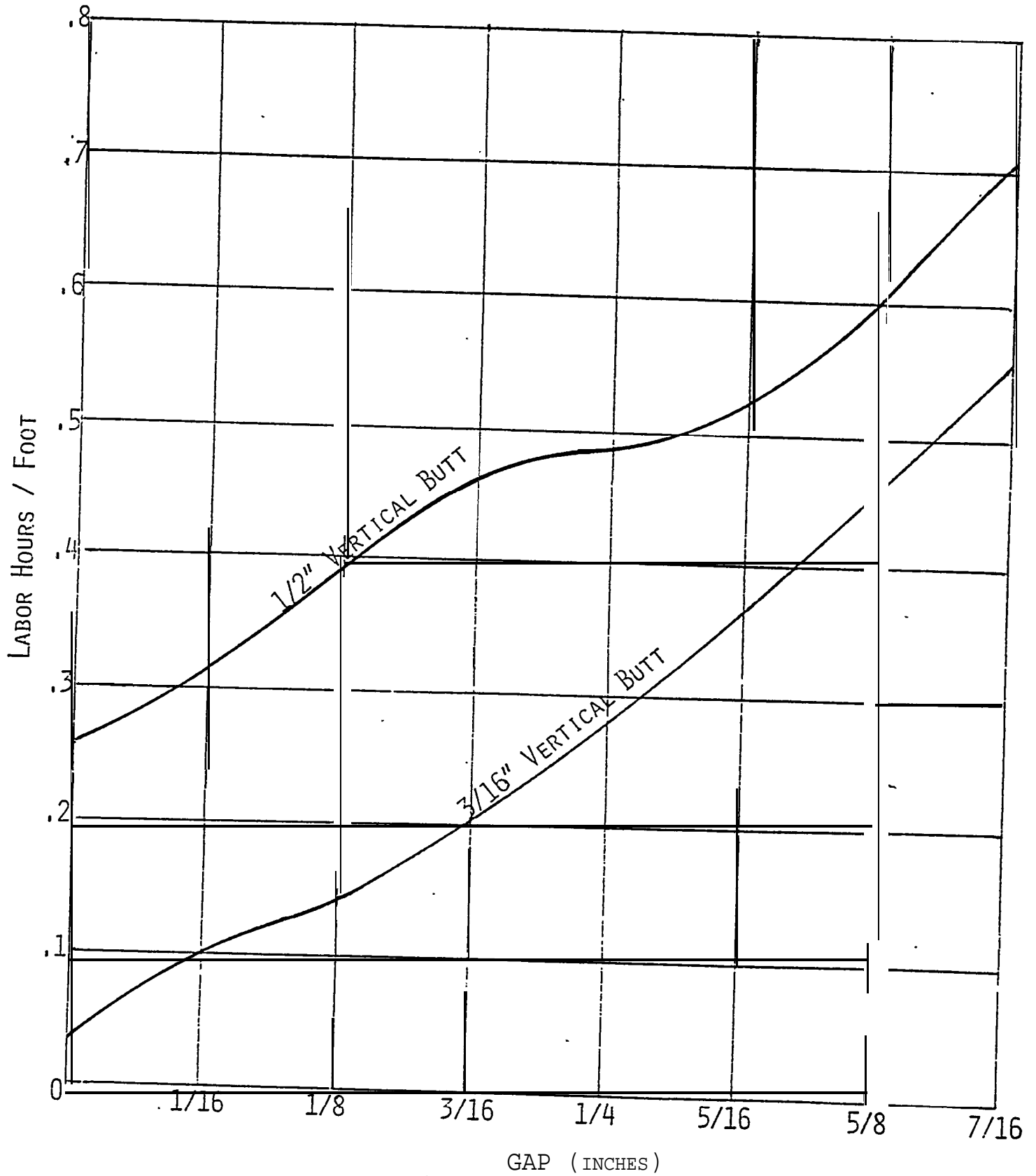
## 7018 HORIZONTAL FILLET WELD

### GAP (ROOT OPENING, INCHES)

		1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2
WELD SIZE (INCHES)	3/16	.019	.039	.090	.119	.137	.197	.301	.405
	1/4	.023	.043	.107	.127	.104	.205	.345	.429
	5/16	.043	.003	.115	.155	.172	.249	.368	.453
	3 / 8	.060	.010	.142	.163	.216	.273	.395	.482
	7/16	.068	.081	.150	.207	.240	.297	.435	.512
	1/2	.095	.115	.194	.231	.264	.327	.465	.531


# ARC TIME vs OPENING

FIRST SIDE - 7018

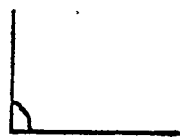


# COST MULTIPLIER ASSEMBLY BUILDING


## HORIZONTAL FILLETS



	<u>WELD SIZE</u>					
	<u>3/16</u>	<u>1/4</u>	<u>5/16</u>	<u>3/8</u>	<u>7/16</u>	<u>1/2</u>
BKHD TO FLAT PANEL	2.2	2.0	1.7	1.5	1.4	1.3
BKHD TO CURVED PANEL	2.4	2.2	1.8	1.6	1.5	1.4
STIFF TO FLAT PANEL	1, 4	1, 4	1, 3	1, 2	1, 2	1, 1
STIFF TO CURVED PANEL	2, 2	2, 0	1, 7	1, 5	1, 4	1, 3

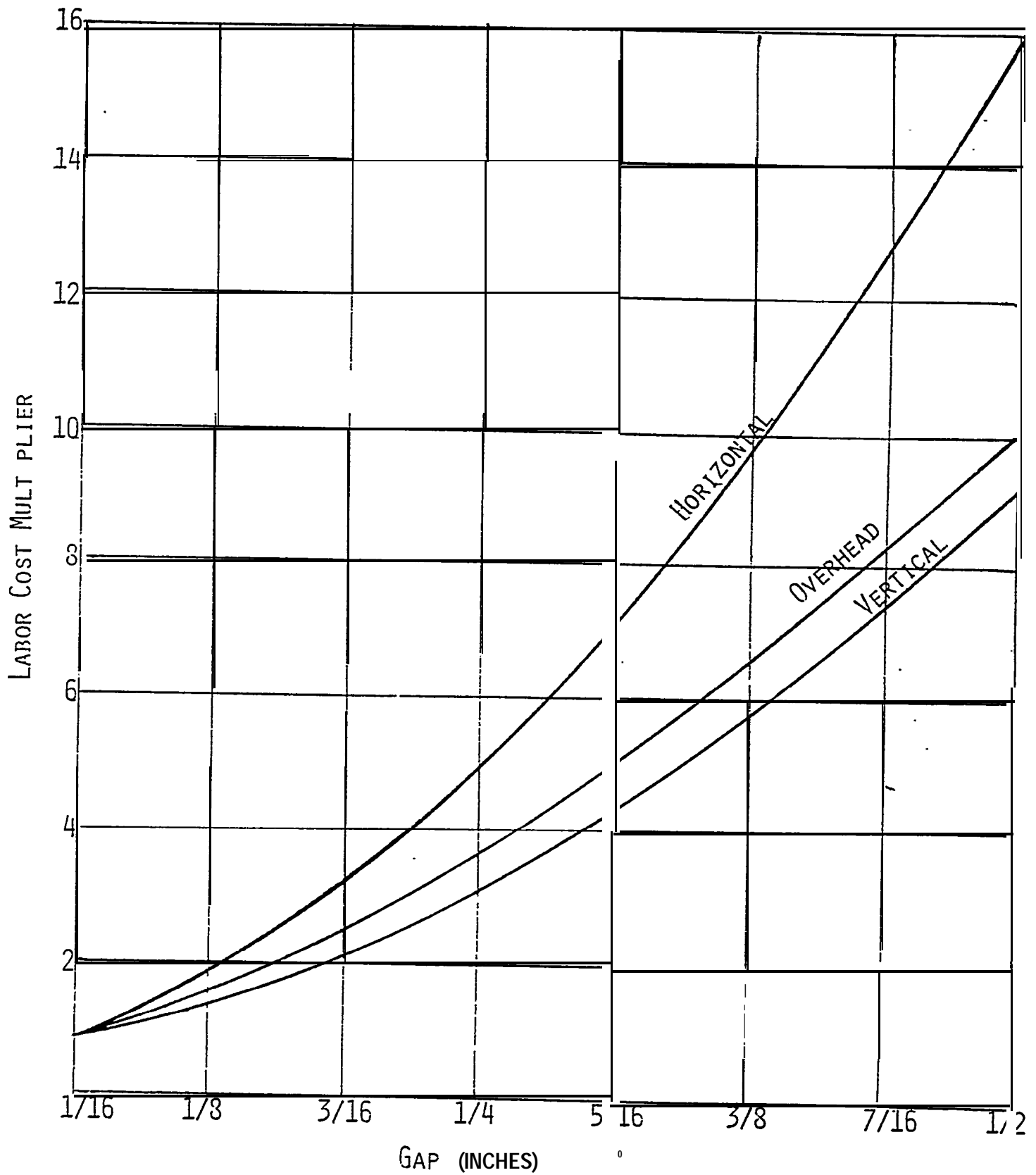


	<u>WELD SIZE</u>					
	<u>3/16</u>	<u>1/4</u>	<u>5/16</u>	<u>3/8</u>	<u>7/16</u>	<u>1/2</u>
BKHD TO FLAT PANEL	2, 4	2, 2	1, 8	1, 6	1, 5	1, 4
BKHD TO CURVED PANEL	3, 2	2, 9	2, 3	1, 9	1, 8	1, 6



	<u>WELD SIZE</u>					
	<u>3/16</u>	<u>1/4</u>	<u>5/16</u>	<u>3/8</u>	<u>7/16</u>	<u>1/2</u>
BKHD TO FLAT PANEL	2, 4	2, 2	1, 8	1, 6	1, 5	1, 4
BKHD TO CURVED PANEL	3, 2	2, 9	2, 3	1, 9	1, 8	1, 6
STIFF TO FLAT PANEL	1, 4	1, 4	1, 3	1, 2	1, 2	1, 1
STIFF TO CURVED PANEL	2, 2	2, 0	1, 7	1, 5	1, 4	1, 3

# WELDING LABOR vs OPENING. FILLET WELDS



COST MULTIPLIERS

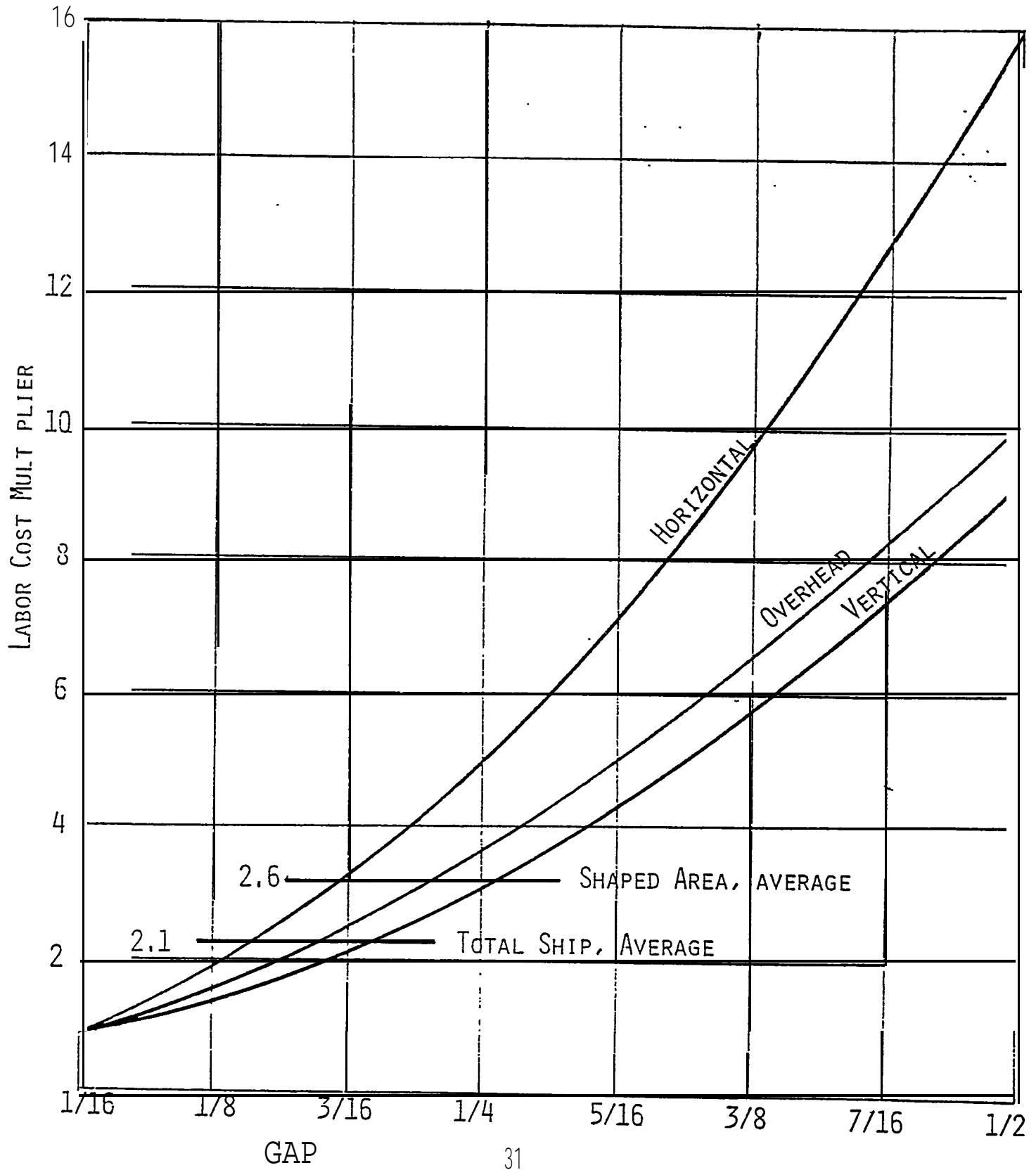
FOR ACTUAL

JOINT OPENINGS

		<u>COST</u> <u>MULTIPLIER</u>
52%	0 - 1/16 INCH	1, 0
22%	1/16 - 1/8 INCH	2, 0
18%	1/8 - 1/4	4, 0
<u>8%</u>	+ 1/4	<u>7, 0</u>
100%	WEIGHTED AVERAGE	2, 1

22% OF THE WELDING IS 1/16" - 1/8" OPEN  
WHICH REQUIRES TWICE AS MUCH LABOR AND  
MATERIAL AS DO TIGHT JOINTS (0 - 1/16"),

WELDING LABOR vs OPENING, FILLET WELDS



## STEPS FOR SAVINGS

- 1) DETERMINE THE PRESENT AVERAGE GAP FOR ALL WELDING AND FOR AREAS THAT WILL BE CUT WITH N/C,
- 2) DETERMINE THE WELDING AND FITTING LABOR FOR-THE WHOLE SHIP,
- 3) ISOLATE THE AREAS IN WHICH N/C BURNING CAN IMPROVE THE FIT AS A PORTION OF THE WHOLE SHIP,
- 4) BASED ON THE PERTINENT VARIABLES AFFECTING WELDING LABOR, QUANTIFY THE PRESENT LABOR FOR FITTING AND WELDING FOR THE WHOLE SHIP AND FOR THE AREA N/C WILL AFFECT,
- 5) CORRELATE THE ABOVE LABOR HOURS WITH THE APPROPRIATE TONS OF STEEL ( FOOTAGE OF WELDING IS MUCH PREFERRED. IF POSSIBLE) TO ARRIVE AT PRESENT MH/T (MANHOURS PER TON) .

$$\begin{aligned} &6) \text{ PRESENT MH/T IN AREA AFFECTED} \\ &\quad \times \text{ TONS AFFECTED} \\ &\quad \times \underline{\underline{\text{PRESENT COST MULTIPLIER}}} \\ &\quad \underline{\hspace{1.5cm}} \\ &\quad \text{PRESENT LABOR} \end{aligned}$$

$$\begin{aligned} &7) \text{ PRESENT MH/T IN AREA AFFECTED} \\ &\quad \times \text{ TONS AFFECTED} \\ &\quad \times \underline{\underline{\text{PROPOSED COST MULTIPLIER}}} \\ &\quad \underline{\hspace{1.5cm}} \\ &\quad \text{PROPOSED LABOR} \end{aligned}$$

$$\begin{aligned} &3) \text{ PRESENT LABOR} \\ &\quad - \underline{\underline{\text{PROPOSED LABOR}}} \\ &\quad \text{NET LABOR SAVINGS PER HULL WITH N/C} \end{aligned}$$



BENEFITS OF CAD  
ADDED TO R.O. I.

- MORE INDEPENDENCE FROM DESIGN AGENT

BETTER PLAN INFORMATION AND ON-TIME COMPLETIONS

- BETTER CHANGE CCNTROL

THE COMPUTER IS FASTER, CHEAPER, MORE ACCURATE

MANHOUR SAVING IN THE LOFT

- BURNING CAPACITY INCREASE AND LABOR SAVINGS

N/C GAS BURNING IS FASTER AND PLASMA IS  
MUCH FASTER THAN GAS

NON-FERROUS AND STAINLESS CUTTING CAPABILITY

PLASMA

SHIP DELIVERY SCHEDULE SAVINGS

## DECISIONS

- BUY AN N/C BURNING MACHINE WITH PLASMA

USE AUTOKON

- LINDE IS THE PRIME SUPPLIER

ŽANDERSON ENGINEERS WATER TABLE CCNVEYOR

- START UP FOURTH QUARTER 1977

Additional copies of this report can be obtained from the  
National Shipbuilding Research and Documentation Center:

**<http://www.nsnet.com/docctr/>**

Documentation Center  
The University of Michigan  
Transportation Research Institute  
Marine Systems Division  
2901 Baxter Road  
Ann Arbor, MI 48109-2150

Phone: 734-763-2465  
Fax: 734-763-4862  
E-mail: [Doc.Center@umich.edu](mailto:Doc.Center@umich.edu)